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Science for Environment Policy

Chemicals applied to fruit after harvesting affect soil microbe function

Wastewaters from fruit-packaging plants may contain preservative chemicals. When spread onto fields, these wastewaters affect the way soil microbes cycle nitrogen, new research has found. Although this may impair crop growth, according to the authors, the results could also lead to the development of new substances that reduce nitrate run-off from agricultural land.

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Source: Papadopoulou, E., Tsachidou, B., Sułowicz, S., Menkissoglu-Spiroudi, U. & Karpouzas, D. (2015) Land spreading of wastewaters from the fruit-packaging industry: are there any effects on soil microbes? The case of the antioxidant ethoxyquin and its metabolites on ammonia oxidizers. *Applied Environmental Microbiology*. DOI:10.1128/AEM.03437-15

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Some fruits, such as apples and pears, are treated with fungicides and antioxidants after harvest to prolong their storage life. Fungicides, such as thiabendazole (TBZ), imazalil (IMZ) and *ortho*-phenylphenol (OPP), are used to control fungal decay. Antioxidants, such as diphenylamine (DPA) and ethoxyquin (EQ), have been used to control deterioration by inhibiting oxidative processes that affect appearance, such as browning of the fruit (although they are no longer approved as plant-protection products in the EU).

Fruit is typically sprayed with solutions of plant-protection chemicals, producing contaminated wastewaters. To date, cleaning these waters has been very expensive and fruit-packaging plants often dispose of them directly into sewage treatment plants, or they are spread onto the surface of nearby fields.

Within the EU, the use of these post-harvest chemicals is regulated[1]. Appropriate waste-management practices must be in place, such as decontaminating the wastewaters or ensuring they are safe to be discharged to the environment by carrying out a risk assessment.

Contaminated waters spread onto fields could harm soil microorganisms. Currently in the EU, the toxicity of pesticides to soil microbes is assessed based on how they affect microbial conversion of organic carbon and nitrogen to inorganic forms.

This study investigated the persistence of TBZ, IMZ, OPP, DPA and EQ and their degradation products in soil, and their impact on soil microbial diversity and activity, factors which are to some extent assessed by EU risk-assessment approaches.

The researchers collected soil samples from an uncultivated plot of land in Thessaloniki, Greece. Five samples were treated with a solution of TBZ, IMZ, OPP, DPA or EQ at a concentration of 50 mg/kg soil dw (50 milligrams of chemical per kilogram of dry-weight soil) — a concentration that reflects a realistic contamination of wastewaters from a medium-sized fruit-packaging plant. Soil samples were incubated for 100 days and regularly tested for the presence of the chemicals.

The analysis showed that IMZ remained the longest in the soil, followed by TBZ, with the amount of time it took for each chemical to break down to half the original concentration being approximately 150 and 47 days respectively. OPP and DPA broke down within around a day, whereas EQ was immediately broken down to oxidation products, which were also quantified.

The researchers also looked at the effect that the pesticides had on the size, structure and activity of soil microbial communities. They tested the contaminated soil samples for enzymes produced by soil microbes that control nutrient cycling. In addition, they extracted genetic material from the soil samples to determine the abundance of two types of soil microbes that play a major role in the nitrification process (whereby ammonium is converted to nitrate).

Continued on next page.

1. Regulation (EC) 1107/2009 concerning the placing of plant protection products on the market. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32009R1107

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None of the post-harvest chemicals were found to have a major effect on the size and structure of the soil microbial communities. However, OPP and especially EQ significantly reduced nitrification compared with the control — despite EQ being broken down within hours of application. Further tests pointed to one of the oxidation products formed upon breakdown of EQ, quinone imine, as being responsible for adverse effects on nitrification.

This suggests that fruit-packaging plant wastewaters containing EQ (which is not approved for use in the EU) could affect soil fertility and crop growth by reducing the conversion of ammonium to nitrate, which is the preferred nitrogen source for plants.

This inhibition may also have balancing effects, as nitrification contributes nitrous oxide (a greenhouse gas) to the atmosphere and produces nitrates that can leach into groundwater, where, depending on their quantity and on local conditions, they can contribute to eutrophication and may be toxic to wildlife. The researchers suggest their results could pave the way for the development of a new nitrification inhibitor, which could be added to fertilisers for more efficient nitrogen conservation in agricultural land. It should be noted that nitrogen mineralisation is currently strictly assessed[2] on the basis of laboratory studies during approval of active substances for use in plant-protection products in the EU.

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2. Commission Regulation (EU) 546/2011: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011R0546&from=EN